Protection Branch Report of Test No. 6-67

Evaluation of Lithium Hydroxide Canisters as Microbial Filters

27 September 1966

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Bacterial penetration evaluation has been completed on two lithium hydroxide canisters designed for use in spacecraft. The request for evaluation by Physical Defense Division was made by Dr. Lawrence F. Dietlein, Chief Biomedical Research, Manned Space Center, NASA, Houston, Texas.

These canisters (approximately $7\frac{1}{4}''$ x $7\frac{1}{4}''$ x $5''$) are designed to remove carbon dioxide and other gases from air inside occupied spacecraft. They are constructed so that approximately 55% of the recycled air passes through a small quantity of charcoal in the center of the canister while the remaining air passes through a bed of lithium hydroxide held in place by a screen and a flannel-like fabric.

The question posed was whether they would be effective in removing particulate matter or microorganisms from the air. During flight an atmosphere containing 98% oxygen at 5 psia will be circulated through these canisters in the spacecraft at a flow rate of 35 cfm. Our present facilities would not permit testing under these conditions. It was believed, however, that the efficiency of the filters in removing one to two micron size particles from normal air at normal pressures would be indicative of biological particulate removal at other flow rates and pressures. Accordingly, an aerosol of *B. globigii* spores (concentration approximately 8.0×10^6 spores per cu ft) was used to challenge the canisters at a flow rate of 12.25 cfm at atmospheric pressure and ambient temperature (75 F).

Three consecutive challenges of 15 minutes duration were made on each canister. The bacterial aerosol generator was then stopped but the air flow through the canister was continued for 16 hours. After this passage, bacteria were again aerosolized and three more 15 minute challenges were made. The pressure drop across the canister and relative humidity of the challenge aerosol were determined during each trial.

Results of these tests are shown in Table I. The data show that the bacterial penetration was extremely high (40-50%). The data also show an increase in the pressure drop and a slight increase in the per cent penetration after air passage for 16 hours. These canisters would not serve to produce bacteria free air; however their effectiveness in a closed system is another matter.

They could be counted upon to remove 50% of the particulate matter from 35 cu ft of air each minute from within the space cabin atmosphere. What the effect of this would be depends upon the total volume of air within the cabin, and the rate at which particulate matter and microorganisms were being released to the atmosphere, presumably by the astronauts. This problem has been considered in "Air Filtration of Microbial Particles" by H.M. Decker, L.M. Buchanan, L.B. Hall, and K.R. Goddard, Public Health Service Publication No. 953, U.S. Government Printing Office, 1962, page 19. A mathematical model was developed which shows that a steady level of bacterial contamination is soon reached. The difficulty of applying this model is that no good data exist on the production rate of biological particulates by the movement of astronauts within their confined cabin space. Thus it is difficult to predict what the equilibrium concentration of microorganisms would be when the filter was in use.

Table I.

Bacterial Evaluation of Lithium Hydroxide Canisters

Filter No.	Test No.	Flow Rate cfm	ΔP in. of H_2O	% R.H.	% Penetration (Ave. of 3 tests)
SN 105-270	1*	12.25	1.09	46	45.2
	2**	12.25	1.13	47	50.3
SN 105-269	1*	12.25	1.14	33	42.9
	2**	12.25	1.2	39	43.9

* Test made immediately after installation.

** Test made after 16 hours passage of air through canister.

Addendum to Protection Branch Report of Test No. 6-67
Dated 27 September 1966

Evaluation of Lithium Hydroxide Canisters as Microbial Filters

In Report of Test No. 6-67, the statement was made that even though the biological efficiency of the canister had been determined, one could not calculate the final equilibrium concentration that would result in the cabin atmosphere when in use, because data were lacking on the rate at which microorganisms would be released to the atmosphere by the astronauts. Mr. Lawrence B. Hall has since furnished approximate values for the missing data and requested that this calculation be made. There were a total of 100,000 organisms per minute released by the crew, a cabin volume of 300 cu ft and 10 air changes per minute. Information received from the Manned Space Center stated that the filter was rated for 35 cu ft per minute flow rate which would result in 7 rather than 10 air changes per minute. Both of these values were used in the calculations.

A mathematical formula for determining the biological contamination reached within any enclosed space was developed and appears in Appendix D of PHS Report No. 953, "Air Filtration of Microbial Particles" by H.M. Decker, L.M. Buchanan, L.B. Hall and K.R. Goddard. The formula takes into account that personnel within the space are releasing microorganisms which are then being removed by having a certain fraction of the air circulate through a filter. Then N, the number of organisms per cubic foot in the air at anytime, t, Min. after the personnel enter, and the filter has been turned on is given in the following formula:

$$N = \frac{60b}{aKV}\left[1 - e^{-\left(\frac{aKt}{60}\right)}\right]$$

Where

V = volume of cabin in spacecraft in cubic feet

K = number of complete changes of spacecraft cabin volume/hour

b = total number of organisms/minute being released in the space because of human presence

a = efficiency of the filter

The following values are used in the solution:

$V = 300$ cu ft

$K = 7$ and 10

$b = 100{,}000$

$a = 50\%$*

$t = 1$ hour, and when equilibrium has been reached.

The solution is as follows:

Spacecraft Cabin Contamination in Organisms per Cubic Foot
At End of One Hour and at Steady State

Time	7 Air Changes/Min.	10 Air Changes/Min.
After one hour	5543	3973
After steady state has been reached	5714	4000

* This figure is based upon information contained in the Report of Test